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Effects of Superselective Embolization for Renal Vascular Injuries on Renal Parenchyma and Function

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Aim. *Our objective was to evaluate the outcome of superselective embolization used for treatment of renal vascular injuries on renal parenchyma and renal function.*
Materials and methods. *Between January 1999 and December 2001, 6 consecutive patients (five males, one female, mean age 45 years) underwent embolization to treat bleeding from renal vascular injuries, resulting from iatrogenic interventions (4) and blunt abdominal trauma (2). Five patients had increased serum creatinine. Angiography depicted a pseudoaneurysm (PA) in three, PA with arteriovenous fistula (AVF) in one, and active extravasation in two patients. Superselective catheterization was achieved using a 5-F catheter in three, and coaxial microcatheter in the remaining three cases. All lesions were successfully embolized with 0.035″ or 0.018″ coils.*
Results. *Bleeding was ceased in all patients and did not recur. Mean post-embolization parenchymal ischemic area was 11.7% (range: 0–30%). Imaging follow-up (mean: 12 months, range: 5–23) showed that mean parenchymal infarcted area was 6% (range: 0–15%). Serum creatinine level was normal in all patients one week after the procedure and at the latest follow-up.*
Conclusion. *Superselective embolization resulted in permanent cessation of bleeding. Serious parenchymal infarction was prevented and serum creatinine level returned to the pre-bleeding values. Embolization should be considered as the treatment of choice in this patient population.*

Key Words: Blunt trauma; Coils; Iatrogenic trauma; Renal vascular injuries; Therapeutic embolization.

Introduction

Renal vascular injuries are caused by iatrogenic trauma in more than 50% of the cases. Stab wounds also constitute a frequent cause, while blunt trauma is less common. Blunt renal trauma usually causes minor and self-limiting injury, however, in some cases the presence of massive hemorrhage or continuous hematuria necessitates aggressive therapy.[1–4]

Angiographic evaluation and management with embolization has emerged as an alternative method to surgical management. This approach has a high technical and clinical success rate as shown by multiple series, employing the technique both in native and transplant kidneys.[5–7]

Complications following an embolization procedure may occur occasionally. Specifically it has a definite risk of inadvertent parenchymal infarction with subsequent detrimental effects on renal function. Few studies report on the unintentional parenchymal infarction,[8–11] and the effects of embolization on renal function.[12]

We report our experience in treating six renal vascular trauma patients with superselective embolization, focusing on the effects of this procedure to renal parenchymal infarction and consequences on renal function.

Materials and Methods

Between January 1999 and December 2001, six consecutive patients (five males, one female, mean age: 45 years) were referred for arteriography and potential transcatheter embolization for symptomatic renal vascular lesions. All patients had been evaluated with contrast enhanced computed tomography that was positive for renal vascular injury.

All patients underwent digital subtraction angiography (DSA) of the aorta and selective renal DSA,

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which demonstrated renovascular injury in all. After identifying the source of vascular bleeding a 5F angiographic catheter (Cobra II, Terumo, Japan) was advanced over a 0.035-inch hydrophilic guide wire (Terumo, Japan) to a superselective position. In three patients a 3F superselective coaxial microcatheter (Target 325,Target Therapeutics, CA, USA) was introduced in the proximity of the bleeding site. 0.035-inch fibered coils, 4 mm × 3 cm, (Boston Scientific, MA, USA) were deployed when a 5F system was used while 0.018-inch complex helical fibered platinum coils, 4 mm × 3 cm, (Target Therapeutics, CA, USA) when coaxial technique was necessary. All embolization procedures were performed by experienced interventional radiologists.

Technical success of the intervention was defined as complete cessation of bleeding, documented by the post procedural angiography. Clinical success was defined as cessation of hematuria within three days with no recurrence during the follow-up period and returning of renal function (determined by creatinine) to normal values.

Renal parenchymal loss (as percentage of the total renal parenchyma) was estimated by comparison of pre and post-embolization angiography during parenchymal phase (two orthogonal views) and from follow-up CT, which was performed within 4 h after the procedure. This estimation was performed quite subjectively, (visual estimation), by two interventional radiologists in consensus.

Clinical follow-up ranged from 5 to 23 months (mean: 12 months). All patients underwent follow-up imaging with contrast enhanced CT, once during the follow-up period with at least a 5 months post embolization interval.

Results

Complete cessation of active bleeding and flow into the bleeding source was achieved in all patients. Lesions treated included four pseudoaneurysms (one with simultaneous arteriovenous fistula) and two cases of uncontained bleeding. Three pseudoaneurysms arose from segmental arteries (one combined with a fistula) while one from an interlobar artery. The two active bleedings were from interlobar arteries and both were treated with coaxial technique. One active bleeding was from a small right polar renal artery. The other bleeding occurred spontaneously in a patient with a small angiomyolipoma who was on high dose of warfarin for deep venous thrombosis (DVT) treatment. Tables 1 and 2 show patients details and outcome.

Table 1. Clinical presentation and laboratory data of patients before and after intervention

Patient	Age	Procedure	Indication for angiography	Duration of symptoms prior to embolization	Ht pre (%)	Ht post* (%)	Cr pre (mg/dl)	Cr post* (mg/dl)	Blood transfusions
A	52	PCNL	Hematuria	21 Days	35	45	2.0	1.2	No
B	23	Blunt trauma	Hematuria hypotension	1 Day	28	46	1.8	0.9	2 ×
C	65	Surgical NL	Hematuria right perirenal hematoma	14 Days	32	45	3.2	0.9	15 ×
D	26	Blunt trauma	Left perirenal hematoma hypotension	1 Day	27	45	1.0	1.0	3 ×
E	45	Spontaneous. AmL on Warfarin for DVT	Hematuria left perirenal hematoma hemodynamic instability	5 Hours	22	44	1.7	1.1	8 ×
F	60	Partial nephrectomy in a single kidney for tumor	Hematuria	12 Days	26	40	2.4	1.9	3 ×

Ht, hematocrite; Cr, serum creatinine concentration; PCNL, percutaneous nephrolithotomy; NL, nephrolithotomy; AmL, angiomyolipoma; DVT, deep venous thrombosis.
*Data obtained at the latest follow-up.

Table 2. Angiographic findings, embolic agents and outcome of the procedures

Patient	Lesion	Catheter	Embolic material	Technical success	Clinical success	Immediate ischemic area (%)	Long-term infarct (%)	Latest follow-up (months)
A	AVF bilobar PA	5F Cobra	0.035″ coil	Yes	Resolution of hematuria	≅ 10	≅ 5	8
B	PA	Tracker catheter	3 × 0.018′ platinum coils	Yes	Resolution of hematuria	≅ 5	≅ 5	23
C	Extravasation	Tracker catheter	2 × 0.018′ platinum coils	Yes	Resolution of hematuria	≅ 30	≅ 15	15
D	PA	5F Cobra	0.035″ coil	Yes	Resolution of hematoma (1 week later)	≅ 10	≅ 5	9
E	Extravasation	Tracker	3 × 0.018 platinum coils	Yes	Resolution of bleeding. Hemodynamic stabilization (immediately)	≅ 0	≅ 0	5
F	PA	5F Cobra	3 × 0.035 coils	Yes	Resolution of hematuria	≅ 15	≅ 5	13

AVF, arteriovenous fistula; PA, pseudoaneurysm.

All patients were successfully treated in a single session, immediately after the diagnostic arteriography (Fig. 1). None needed further, surgical or percutaneous intervention. In patients with hematuria due to arteriocalyceal connection, urine cleared macroscopically within 4 days in all and microscopically by the day of discharge from the hospital. All patients returned to normal renal function when discharged from the hospital except the patient with prior contralateral total nephrectomy and ipsilateral partial nephrectomy. The latter patient stabilized at a 1.9 mg/dl creatinine level lower from the 2.4 mg/dl before the embolization. No patient developed the so-called post embolization syndrome, abscess or other delayed complications. The embolization procedure resulted in an ischemic area of 0–30% (mean 12%) of total renal parenchyma, as documented by the orthogonal views of the post-embolization arteriography. Additionally, the comparison of the post-embolization CT with the follow-up CT scan revealed that the initial ischemic area evolved to a less extended infarct, ranged between 0 and 15% (mean 6%) of total renal parenchyma.

Discussion

The treatment of renal vascular injuries depends on the etiology and the clinical course of the disease. Hemorrhagic complications after percutaneous urological procedures are initially managed with tamponade of the percutaneous tract with a large-bore catheter. In non-iatrogenic renal trauma patients, decision for surgical versus conservative management is difficult and depends largely on the general status of the patient. Surgical intervention is performed in roughly 10% of renal injuries and declines with the increasing availability of the percutaneous techniques.[2–7] Renal arteriography and embolization provide an effective means for the management of these patients.[4–8] All types of injury (even shattered or avulsed kidney) can be treated with embolization techniques. Most of the time this may result in less parenchymal sacrifice since the alternative is total nephrectomy.[8–16]

In our study, all patients were referred directly for arteriography and embolization. In five patients, the signs and symptoms of renal bleeding presented immediately after trauma and had a duration of between a few hours and 21 days. In hemodynamically stable patients, it is generally agreed that intervention should be undertaken, if hemorrhage persists for more than 72 h, or if there is a marked deterioration of renal function.[10] We believe that

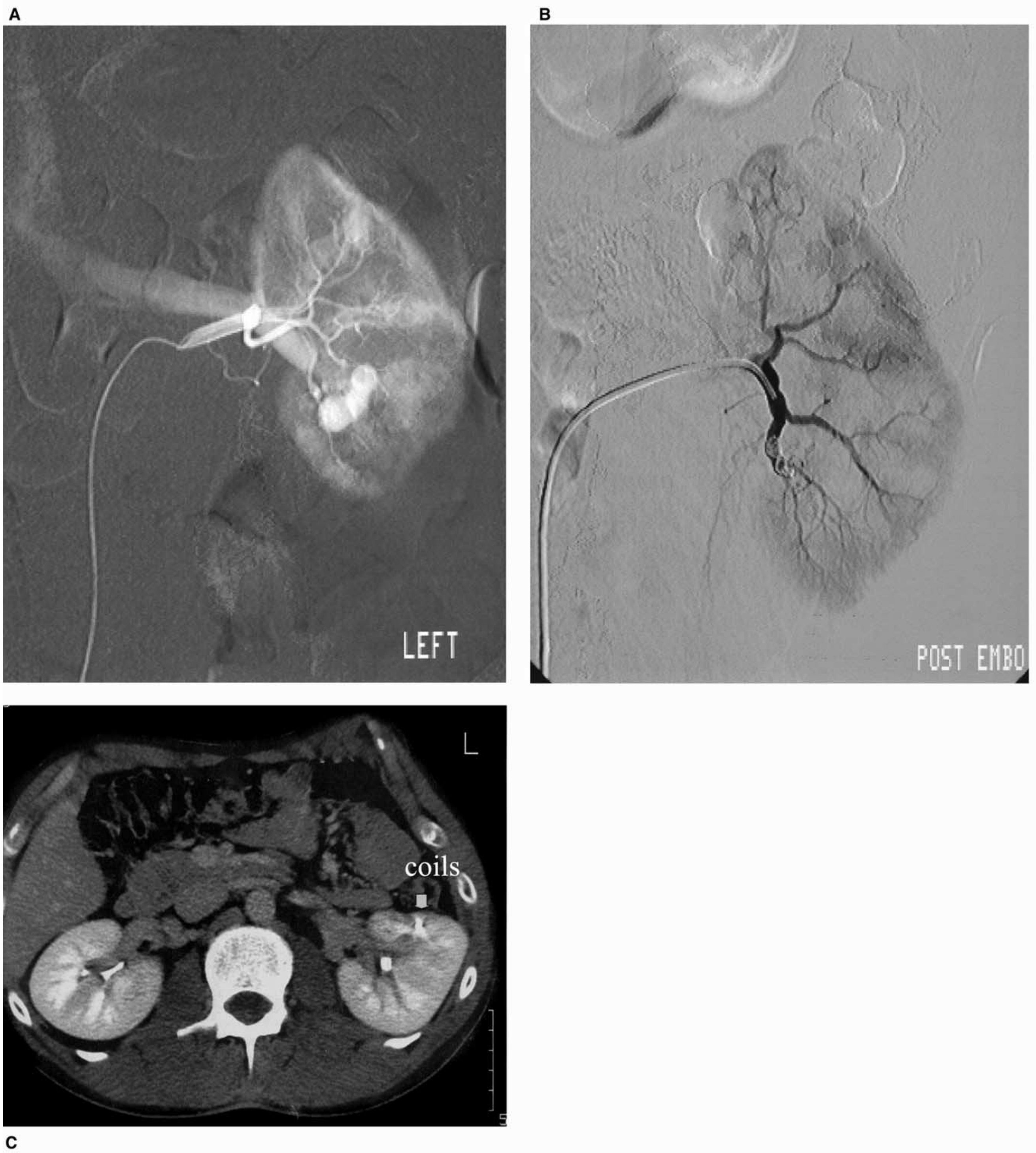

Fig. 1. (A) Selective renal DSA depicting a bilobar pseudoaneurysm with simultaneous arteriovenous fistula. (B) DSA after superselective embolization with 0.035-inch coils shows total occlusion of the injury site with minimal non-perfused area of the renal parenchyma. (C) Contrast enhanced CT 8 months after the embolization shows no significant residual parenchymal infarction. The hyperdense area within the parenchyma represents the coils (arrow).

immediate intervention should be instituted whenever there are signs of significant blood loss.

While attempting to embolize the culprit lesion as selectively as possible, we found that whenever superselective catheterization was difficult with the standard catheter, the use of coaxial microcatheters greatly facilitated the procedure. We share the experience of other authors, that acute curving of the microcatheter does not impede the delivery of platinum microcoils in the desired location.[10,15] We did not use microcatheter systems when not necessary, to reduce the procedural duration and costs.

Cessation of flow in the lesion was achieved in all our patients. In the relevant literature, success rates range between 71 and 100%.[1–20] Advances in catheter technology have not significantly improved the technical success of the procedure. Although Dinkel *et al*. and Huppert *et al*. reported a 100% technical success rate,[4,10] Dorffner *et al*. and Perini *et al*. recently, reported success rates of 71 and 95%, respectively.[11,12] The outcome is clearly dependent on the degree of procedure difficulty of selected cases.

We experienced clinical success in all our patients. Clinical and technical success do not always parallel each other in prior published series, due to recurrent bleeding from the initially embolized lesions.[7,9,13,14] We achieved a durable clinical effect by applying a meticulous embolization technique. In two recently published series,[11,12] clinical success was lower than the technical success, 57 and 88%, respectively. In both series clinical failure was the progression of already impaired renal function. It was postulated that the embolization procedure resulted in further deterioration of renal function, as a consequence of inadvertent parenchymal infarction.

As indicated above, renal infarction is the main risk factor for renal functional impairment and clinical failure after embolization. Using superselective technique we reduced the extent of the initial renal ischemic area to a mean of 12%. In the literature, the use of a less selective technique was associated with large infarcts,[8,9] while superselective catheter techniques reduce the infarct extent to 0–15%.[11]

Long-term imaging follow-up is not available in the majority of the published series. We used contrast enhanced renal CT to follow-up all our patients. The subsequent infarcted area was notably smaller at a mean 6% when compared to the initial ischemic area, mean of 12%. This finding may be due to intrarenal collateral supply, which retransfuses the initial ischemic area and prevents total infarction from occurring. Although the renal arteries have been considered end arteries, intrarenal anastomoses do exist via the perivascular plexuses of segmental, interlobar and arcuate arteries.[21] Another parameter, resulting in a smaller infarcted area at the long-term follow-up, is the fact that infarcts are considered as scars and scars have the tendency to shrink.

Serum creatinine was abnormal in five of six patients at the time of intervention. We believe that a degree of obstructive uropathy was present in all of the patients presenting with hematuria, due to blood clots obstructing the renal pelvis and ureter. Serum creatinine returned to normal in all patients after resolution of hematuria except the patient with a single kidney who stabilized at a borderline value.

In summary, we have demonstrated that technically successful selective embolization techniques are effective for renal trauma, resulting in immediate and long-lasting resolution of the symptoms. Additionally we have shown that careful superselective techniques (coaxial or no coaxial) minimize the extent of renal parenchymal infarction, allowing the highest possible level of preservation of renal function.

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